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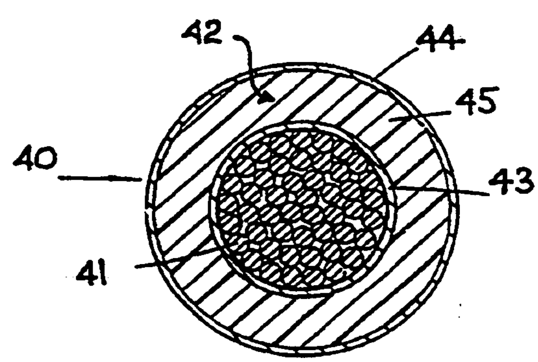
(57) Abstract

An earthing transformer (1) having a core (3) and, wound on the core (3), windings (9a–11a, 9b–11b) each comprising electrical conducting means (41) and surrounding electrically insulating means (42). The electrically insulating means (42) comprises magnetically permeable solid material within which the electric field is confined in use of the transformer.



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A Transformer

Technical Field

This invention relates to an earting transformer, e.g. a 3-phase earthing transformer of the kind having a core and, wound on the core, windings each comprising electrical conducting means and surrounding electrically insulating means. Such an earthing transformer is intended to be used for the protection of a supply system, such as a three-phase delta connected power system.

Background of the Invention

It is sometimes necessary to earth a part of a supply system which has no existing means of earthing. For example, if the windings of two transformers are individually star/delta and delta/star connected in series, the circuit connecting the two delta windings has no neutral earthing point. It is thus necessary to artificially introduce a neutral point by using auxiliary apparatus. A three-phase earthing transformer is specially designed for such a purpose since it offers an earthed neutral point and is thus able to protect the system against line to ground faults. A conventional three-phase earthing transformer of the kind referred to has its core windings electrically insulated with oil and cellulose insulation.

The transformer oil of a conventional transformer is contained within a metal transformer tank within which the core and windings are immersed. The tank and oil form a considerable part of the total weight of the transformer and significantly increase the production and transport costs of the transformer. The oil, in addition to its electrically insulating function, also serves to cool the core and windings by the removal of "loss" heat of the transformer. However this oil cooling function necessitates the provision of additional equipment, such as an oil pump, an external cooling element, an expansion coupling, etc., which again

increases the production cost of the transformer. The transformer oil also has a relatively low flash point which, together with the cellulose insulation, constitutes a non-negligible fire hazard. In the event of damage of, or an accident to, the transformer any resultant oil spillage could lead to extensive environmental damage.

For good electrical insulation of a conventional oil/cellulose insulated transformer, the insulation system must have a low moisture content. The cellulose insulation needs to be well impregnated with the surrounding oil so that there is a minimal risk of "gas" pockets being present in the solid cellulose insulation. To ensure this, a special drying and impregnating process is carried out on the complete core and windings before they are positioned as a unit in the tank. After this drying and impregnating process, the core and windings are lowered into the tank and the tank is sealed. The tank containing the core and windings is then emptied of all air by a special vacuum treatment before finally being filled with the oil. To be able to achieve the promised service life, it is necessary during the vacuum treatment to pump the tank out to almost absolute vacuum. It is therefore necessary for the tank to be made sufficiently strong to withstand a full, or almost full, vacuum. Thus the entire manufacturing process is relatively time-consuming, complicated and expensive.

Summary of the Invention

An aim of the present invention is to provide an earthing transformer having windings with improved electrical insulation.

According to one aspect of the present invention an earthing transformer, e.g. a 3-phase earthing transformer, of the kind referred to is characterised in that the electrically insulating means comprises magnetically permeable solid plastics material within which the electric field is confined in use of the transformer.

According to another aspect of the present invention an earthing transformer of the kind referred to is characterised in that the electrically insulating means is of substantially unitary construction comprising an inner layer of semiconducting material in electrical contact with said electrical conducting means, an outer layer of semiconducting material at a controlled electrical potential along its length and an intermediate layer of electrically insulating material between the said inner and outer layers.

In this specification the term "semiconducting material" means a material which has a considerably lower conductivity than an electric conductor but which does not have such a low conductivity that it is an electrical insulator. Suitably, but not exclusively, the semiconducting material should have a volume resistivity of from 1 to 10^5 ohm·cm, preferably from 10 to 500 ohm·cm and most preferably from 10 to 100 ohm·cm, typically about 20 ohm·cm.

The electrical insulation is of unitary form with the layers either in close mechanical contact or, more preferably, joined together, e.g. bonded by extrusion. The layers are preferably formed of plastics material having resilient or elastic properties at least at ambient operating temperatures. This allows the cable forming the winding to be flexed and shaped into the desired form of the winding. By using for the layers only materials which can be manufactured with few, if any, defects having similar thermal properties, thermal and electric loads within the insulation are reduced. In particular the insulating intermediate layer and the semiconducting inner and outer layers should have at least substantially the same coefficients of thermal expansion (α) so that defects caused by different thermal expansions when the layers are subjected to heating or cooling will not arise. Ideally the layers will be extruded together around the conducting means.

Conveniently the electrically insulating intermediate layer comprises solid thermoplastics material, such as low or high density polyethylene (LDPE or HDPE), polypropylene (PP), polybutylene (PB), polymethylpentene (PMP), ethylene (ethyl) acrylate polymer, polyvinyl chloride (PVC), cross-linked materials, such as cross-linked polyethylene (XLPE), or rubber insulation, such as ethylene propylene rubber (EPR), ethylene-propylene-diene monomer (EPDM) or silicone rubber. The semiconducting inner and outer layers may comprise similar material to the intermediate layer but with conducting particles, such as particles of carbon black or metallic particles, embedded therein. Generally it has been found that a particular insulating material, such as EPR, has similar mechanical properties when containing no, or some, carbon particles. The intermediate layer may be divided into two or more sub-layers.

The screens of semiconducting inner and outer layers form substantially equipotential surfaces on the inside and outside of the insulating intermediate layer so that the electric field is confined between the inner and outer layers in the intermediate layer. In the case of concentric semiconducting and insulating layers, the electric field is substantially radial and confined within the intermediate layer. In particular, the semiconducting inner layer is arranged to be in electrical contact with, and to be at the same potential as, the conducting means which it surrounds. The semiconducting outer layer is designed to act as a screen to prevent losses caused by induced voltages. Induced voltages in the outer layer could be reduced by increasing the resistance of the outer layer. The resistance can be increased by reducing the thickness of the outer layer but the thickness cannot be reduced below a certain minimum thickness. The resistance can also be increased by selecting a material for the layer having a higher resistivity. On the other hand, if the resistivity of the semiconducting outer layer is too great, the voltage potential midway between adjacent spaced apart points at a controlled, e.g. earth, potential will become sufficiently high as to risk the occurrence of corona discharge in the

insulation with consequent erosion of the insulating and semiconducting layers. The semiconducting outer layer is therefore a compromise between a conductor having low resistance and high induced voltage losses but which is easily connected to a controlled potential, typically earth or ground potential, and an insulator which has high resistance with low induced voltage losses but which needs to be connected to the controlled potential along its length. Thus the resistivity ρ_s of the semiconducting outer layer should be within the range $\rho_{min}<\rho_s<\rho_{max}$, where ρ_{min} is determined by permissible power loss caused by eddy current losses and resistive losses caused by voltages induced by magnetic flux and ρ_{max} is determined by the requirement for no corona or glow discharge.

If the semiconducting outer layer is earthed, or connected to some other controlled potential, at spaced apart intervals along its length, there is no need for an outer metal shield and protective sheath to surround the semiconducting outer layer. The diameter of the cable is thus reduced allowing more turns to be provided for a given size of core winding.

Suitably the transformer has primary and secondary windings which are connected in an interconnected star connection or a star/delta connection.

Conveniently the thickness of the electrically insulating means is reduced along the length of the winding from its high voltage end to its low voltage end. In practice the thickness of the electrically insulating means is reduced in one or more steps. In a delta connection of windings, the thickness of the electrically insulating means at opposite ends of each winding in the delta connection will suitably be substantially the same, but the thickness will reduce from either end of the winding towards a central portion of the winding.

The transformer is suitably provided with cooling means, e.g. air cooling means or liquid cooling means arranged around the core and windings.

The core conveniently comprises three core limbs arranged in the same plane or in a triangular arrangement, i.e. along the edges of a triangular prism.

Brief Description of the Drawings

Embodiments of the invention will now be described, by way of example only, with particular reference to the accompanying drawings, in which:

Figure 1a is a circuit diagram showing one embodiment of a three-phase earthing transformer according to the invention connected to a three-phase delta connected system, the transformer having its windings connected in an interconnected star configuration;

Figure 1b is a circuit diagram showing another embodiment of a three-phase earthing transformer according to the invention connected to a three-phase delta-connected system of the kind shown in Figure 1a, the transformer having its windings connected in a star/delta configuration;

Figures 2a and 2b are similar to Figures 1a and 1b, respectively, but schematically illustrating the earthing transformers and associated circuitry;

Figure 3 is a schematic cross-sectional view through a winding cable of an earthing transformer according to the invention;

Figure 4 is a schematic view of star-connected windings of an earthing transformer according to the invention having stepped electrically insulating means; and

Figure 5 is a schematic view of a winding of an earthing transformer having stepped electrically insulating means.

Figures 1a and 2a show a three-phase earthing transformer, generally designated 1, connected to a previously unearthed delta-connected system 2. The transformer 1 comprises a core, generally designated 3 (see Figure 2a), having core legs 4, 5 and 6 arranged in a plane and connected by upper and lower yokes 7 and 8, primary windings 9a, 10a and 11a and secondary windings 9b, 10b and 11b. The windings 9a and 9b are wound on the core leg 4, the windings 10a and 10b are wound on the core leg 5 and the windings 11a and 11b are wound on the core leg 6. The primary windings are connected in a zigzag or interconnected star arrangement with the common or neutral "point" 12 connected to earth 13. The primary windings 9a, 10a and 11a have cable winding terminations 14, 15 and 16, respectively, which are respectively connected to switches 17, 18 and 19 via current-limiting resistors 20, 21 and 22. The switches 17, 18 and 19 connect the windings 9a, 10a and 11a to the three power phases or lines 23, 24 and 25, respectively.

Under normal conditions, the voltages from each line 23, 24 and 25 to earth are maintained, the current taken by the transformer 1 being the magnetising current only. Under fault conditions, the earthing transformer provides low, zero-sequence impedance to the flow of single phase fault current. The windings 9a, 9b, 10a, 10b, 11a and 11b are designed to carry the maximum possible fault current to which they may be subjected for a short period time (in the order of seconds or tens of seconds).

Figures 1b and 2b show an alternative form of earthing transformer 30 connected to the same delta-connected system 2 as that shown in Figures 1a and 2a. In Figures 1b and 2b, the same reference numerals have been used as those used in Figures 1a and 2a to identify the same or similar parts. The only difference in the two

arrangements is in the connection of th windings of the transformer 30. In the transformer 30, the primary windings 9a, 10a and 11a are connected in a star configuration with the common or neutral point 12 connected to earth 13. The secondary windings 9b, 10b and 11b are arranged in a closed delta configuration. Under fault conditions, the closed delta windings act to distribute the fault currents in all three phases on the primary side of the transformer. Since primary and secondary fault ampere-turns balance each other, there is no transient choking effect.

In the two arrangements described, the current-limiting resistors 20 - 22 are provided, if required, to limit the fault current. These current limiting resistors may be provided between the system lines and the transformers (as shown) or between the transformers and the neutral earthed point.

The earthing transformers 1 and 30 and earthing systems as described above are entirely conventional. The novel features of an earthing transformer according to the invention is in the construction of the primary and secondary windings which enables the conventional transformer oil to be dispensed with. In particular each winding is formed from winding cable 40 (see Figure 3) having inner conductor means 41 comprising a plurality of conductors and surrounding electrical insulation 42.

The electrical insulation 42 is of unified form and comprises an inner layer 43 of semiconducting material, an outer layer 44 of semiconducting material and, sandwiched between these semiconducting layers, an insulating layer 45. At least one of the conductors of the conductor means 41 has its insulation, e.g. varnish insulation, removed therefrom so that the inner layer 43 is in electrical contact with the conductor means 41. The layers 43 - 45 preferably comprise thermoplastics materials in close mechanical contact or preferably solidly connected to each other at their interfaces. Conveniently these thermoplastics materials

have similar coefficients of thermal expansion and are resilient or elastic at least at room temperature. Preferably the layers 43 - 45 are extruded together around the inner conducting means to provide a monolithic structure so as to minimise the risk of cavities and pores within the electrical insulation. The presence of such pores and cavities in the insulation is undesirable since it gives rise to corona discharge in the electrical insulation at high electric field strengths.

By way of example only, the solid insulating layer 45 may comprise cross-linked polyethylene (XLPE). Alternatively, however, the solid insulating layer may comprise other cross-linked materials, low density polyethylene (LDPE), high density polyethylene (HDPE), polypropylene (PP), polyvinyl chloride (PVC) or rubber insulation, such as ethylene propylene rubber (EPR), ethylene-propylene-diene monomer (EPDM) or silicone rubber. The inner and outer layers 43 and 44 of semiconducting material may comprise, for example, a base polymer of the same material as the solid insulating layer 45 and highly electrically conductive particles, e.g. particles of carbon black or metallic particles, embedded in the base polymer. The volume resistivity, typically about 20 ohm·cm, of these semiconductive layers may be adjusted as required by varying the type and proportion of carbon black added to the base polymer. The following gives an example of the way in which the volume resistivity can be varied using different types and quantities of carbon black.

Base Polymer	Carbon Black Type	Carbon Black Quantity (%)	Volume Resistivity Ω·cm
Ethylene vinyl acetate copolymer/ nitrite rubber	EC carbon black	~15	350-400
-"-	P-carbon black	~37	70-10
-"-	Extra conducting carbon black, type I	~35	40-50
-"-	Extra conducting black, type II	~33	30-60
Butyl grafted polyethylene	-"-	~25	7-10
Ethylene butyl acrylate copolymer	Acetylene carbon black	~35	40-50
-"-	P carbon black	~38	5-10
Ethylene propene rubber	Extra conducting carbon black	~35	200-400

The outer semiconducting layer 44 is connected at spaced apart regions along its length to a controlled potential. In most practical applications this controlled potential will be earth or ground potential, the specific spacing apart of adjacent earthing points being dependent on the resistivity of the layer 44.

Although not shown the transformers may be provided with conventional air or liquid cooling means.

The semiconducting layer 44 acts as a static shield and as an earthed outer layer which ensures that the electric field of the winding cable is retained within the solid insulation between the semiconducting layers 43 and 44. Losses caused by induced voltages in the layer 44 are reduced by increasing the resistance of the layer 44. However, since the layer 44 must be at least of a certain minimum thickness, e.g. no less than 0.8 mm, the resistance can only be increased by selecting the material of the layer to have a relatively high resistivity. The resistivity cannot be increased too much, however, else the voltage of the layer 44 mid-way between two adjacent earthing points

will be too high with the ass ciated risk of corona discharges occurring.

The thickness of the electrical insulation need not be uniform along the length of the winding. The thickness needs to be greater for high voltages and need not be as thick for lower voltages. Accordingly the thickness of the electrical insulation may be stepped along its length, the thicker insulation being at the high voltage end(s) of the winding. Cables with different insulation thicknesses may be joined together to form a particular winding.

Figure 4 shows three windings 50, 51 and 52 joined together in a star configuration with the common neutral point connected to earth. The electrical insulation of each winding is stepped along its length, with the thickest insulation at the high voltage end of the winding and the thinnest insulation at the low voltage end of the winding.

Figure 5 schematically illustrates three turns 60, 61 and 62 of a winding within a core window 63 of core 63a of an earthing transformer. The electrical insulation reduces in thickness from the high voltage turn 60 to the low voltage turn 62. The semiconducting outer layer of the winding is earthed along its length as shown at 64.

The transformer windings are made from winding cable having inner conductor means 41 and a surrounding electrical insulation 42. Although the inner conducting means have been described as comprising a plurality of conductors, such conductors could be replaced by superconducting means, e.g. elongate high temperature. Superconducting material such as tapes, threads or wires of BSCCO material, wound around a support tube through which cryogenic fluid, such as liquid nitrogen, is passed.

Although the invention has been described specifically with reference to a 3-phase earthing

transformer, the invention may be applied to any multi-phase earthing transformer.

The electrical insulation of an earthing transformer according to the invention is intended to be able to handle very high voltages and the consequent electric and thermal loads which may arise at these voltages. By way of example, an earthing transformer according to the invention may have a rated power of more than 1000 MVA and with a rated voltage of up to 400kV to 800 kV or higher. At high operating voltages, partial discharges, or PD, constitute a serious problem for known winding insulation systems. If cavities or pores are present in the insulation, internal corona discharge may arise whereby the insulating material is gradually degraded eventually leading to breakdown of the insulation. The electric load on the electrical winding insulation of an earthing transformer according to the present invention is reduced by ensuring that the inner layer of the insulation is at substantially the same electric potential as the inner conducting means and the outer layer of the insulation is at a controlled, e.g. earth, potential. Thus the electric field in the intermediate layer of insulating material between the inner and outer layers is distributed substantially uniformly over the thickness of the intermediate layer. Furthermore, by having materials with similar thermal properties and with few defects in the layers of the insulating material, the possibility of PD is reduced at a given operating voltages. The transformer is thus able to withstand very high operating voltages, typically up to 800 kV or higher.

Although it is preferred that the electrically insulating means should be extruded in position, it is possible to build up an electrical insulation system from tightly wound, overlapping layers of film or sheet-like material. Both the semiconducting layers and the electrically insulating layer can be formed in this manner. An insulation system can be made of an all-synthetic film with inner and outer semiconducting layers or portions made

of polymeric thin film of, for example, PP, PET, LDPE or HDPE with embedded conducting particles, such as carbon black or metallic particles and with an insulating layer or portion between the semiconducting layers or portions.

For the lapped concept a sufficiently thin film will have butt gaps smaller than the so-called Paschen minima, thus rendering liquid impregnation unnecessary. A dry, wound multilayer thin film insulation has also good thermal properties.

Another example of an electrical insulation system is similar to a conventional cellulose based cable, where a thin cellulose based or synthetic paper or non-woven material is lap wound around a conductor. In this case the semiconducting layers, on either side of an insulating layer, can be made of cellulose paper or non-woven material made from fibres of insulating material and with conducting particles embedded. The insulating layer can be made from the same base material or another material can be used.

Another example of an insulation system is obtained by combining film and fibrous insulating material, either as a laminate or as co-lapped. An example of this insulation system is the commercially available so-called paper polypropylene laminate, PPLP, but several other combinations of film and fibrous parts are possible. In these systems various impregnations, such as mineral oil, can be used.

CLAIMS

1. An earthing transformer having a core and, associated with the core, windings each comprising electrical conducting means and surrounding electrically insulating means, characterised in that the electrically insulating means comprises magnetically permeable solid material within which the electric field is confined in use of the transformer.

2. A transformer according to claim 1, characterised in that the electrically insulating means comprises an inner layer of semiconducting material in electrical contact with said electrical conducting means, an outer layer of semiconducting material at a controlled electrical potential along its length and an intermediate layer of electrically insulating material between the said inner and outer layers.

3. An earthing transformer having a core and, wound on the core, windings each comprising electrical conducting means and surrounding electrically insulating means, characterised in that the electrically insulating means is of substantially unitary construction comprising an inner layer of semiconducting material in electrical contact with said electrical conducting means, an outer layer of semiconducting material at a controlled electrical potential along its length and an intermediate layer of electrically insulating material between the said inner and outer layers.

4. A transformer according to claim 2 or 3, characterised in that the semiconducting outer layer has a resistivity of from 1 to 10^5 ohm·cm.

5. A transformer according to claim 2 or 3, characterised in that the semiconducting outer layer a resistivity of from 10 to 500 ohm·cm, preferably from 10 to 100 ohm·cm.

6. A transformer according to any one of claims 2 to 5, characterised in that the resistance per axial unit length of the semiconducting outer layer is from 5 to 50,000 $ohm.m^{-1}$.

7. A transformer according to any one of claims 2 to 5, characterised in that the resistance per axial unit of length of the semiconducting outer layer is from 500 to 25,000 $ohm.m^{-1}$, preferably from 2,500 to 5,000 $ohm.m^{-1}$.

8. A transformer according to any one of claims 2 to 7, characterised in that the semiconducting outer layer is contacted by conductor means at said controlled electrical potential at spaced apart regions along its length, adjacent contact regions being sufficiently close together that the voltages of mid-points between adjacent contact regions are insufficient for corona discharges to occur within the electrically insulating means.

9. A transformer according to any one of claims 2 to 8, characterised in that said controlled electrical potential is at or close to ground potential.

10. A transformer according to any one of claims 2 to 9, characterised in that the said intermediate layer is in close mechanical contact with each of said inner and outer layers.

11. A transformer according to any one of claims 2 to 9, characterised in that the said intermediate layer is joined to each of said inner and outer layers.

12. A transformer according to claim 11, characterised in that the strength of the adhesion between the said intermediate layer and the semiconducting outer layer is of the same order of magnitude as the intrinsic strength of the material of the intermediate layer.

13. A transformer according to claim 11 or 12, characterised in that the said layers are joined together by extrusion.

14. A transformer according to claim 13, characterised in that the inner and outer layers of semiconducting material and the insulating intermediate layer are applied together over the conducting means through a multi layer extrusion die.

15. A transformer according to any one of claims 2 to 14, characterised in that said inner layer comprises a first plastics material having first electrically conductive particles dispersed therein, said outer layer comprises a second plastics material having second electrically conductive particles dispersed therein, and said intermediate layer comprises a third plastics material.

16. A transformer according to claim 15, characterised in that each of said first, second and third plastics materials comprises an ethylene butyl acrylate copolymer rubber, an ethylene-propylene-diene monomer rubber (EPDM), an ethylene-propylene copolymer rubber (EPR), LDPE, HDPE, PP, PVC, XLPE, EPR or silicone rubber.

17. A transformer according to claim 15 or 16, characterised in that said first, second and third plastics materials have at least substantially the same coefficients of thermal expansion.

18. A transformer according to claim 15, 16 or 17, characterised in that said first, second and third plastics materials are the same material.

19. A transformer according to any one of the preceding claims, characterised in that the windings comprise primary and secondary windings connected in an interconnected star connection.

20. A transformer according to any one of claims 1 to 18, characterised in that the windings comprise primary and secondary windings connected in a star/delta connection.

21. A transformer according to any one of the preceding claims, characterised in that the thickness of the electrically insulating means in a star connected winding is reduced along the length of the winding from a high voltage end to a low voltage end of the winding.

22. A transformer according to claim 21, characterised in that the thickness of the electrically insulating means is reduced in one or more steps.

23. A transformer according to claim 21 or 22 each when dependent on claim 20, characterised in that the thickness of the electrically insulating means of a delta connected winding is greater at opposite ends of the winding than at a central portion of the winding.

24. A transformer according to any one of the preceding claims, characterised in that cooling means, e.g. air or liquid cooling means, are provided for cooling the core and windings.

25. A transformer according to any one of the preceding claims, characterised in that the core comprises three core limbs arranged in the same plane.

26. A transformer according to any one of claims 1 to 24, characterised in that the core comprises three core limbs in a triangular arrangement.

27. A transformer according to any of the preceding claims in which low and high voltage windings are mixed together to reduce the leakage inductance.

28. A transformer according to any ne of the preceding claims, characterised in that the electrical conducting means comprises a plurality of conductors.

29. A transformer according to any one of claims 1 to 27, characterised in that the electrical conducting means comprises superconductor means and cooling means for cooling the superconductor means to below it critical temperature.

30. A transformer according to claim 29, characterised in that the cooling means comprises a tube through which cryogenic fluid is passed and in that the superconductor means is of elongate form and is wound around the said tube.

31. A transformer according to claim 29 or 30, characterised in that the superconductor means comprises high temperature superconducting (HTS) material.

32. A transformer according to any one of the preceding claims, characterised in that the said electrically insulating means is designed for high voltage, suitably in excess of 10 kV, in particular in excess of 36 kV, and preferably more than 72.5 kV up to very high transmission voltages, such as 400 kV to 800 kV or higher.

33. A transformer according to any one of the preceding claims, characterised in that the said electrically insulating means is designed for a power range in excess of 0.5 MVA, preferably in excess of 30 MVA and up to 1000 MVA.

34. A 3-phase delta-connected power system including an earthing transformer according to any preceding claim.

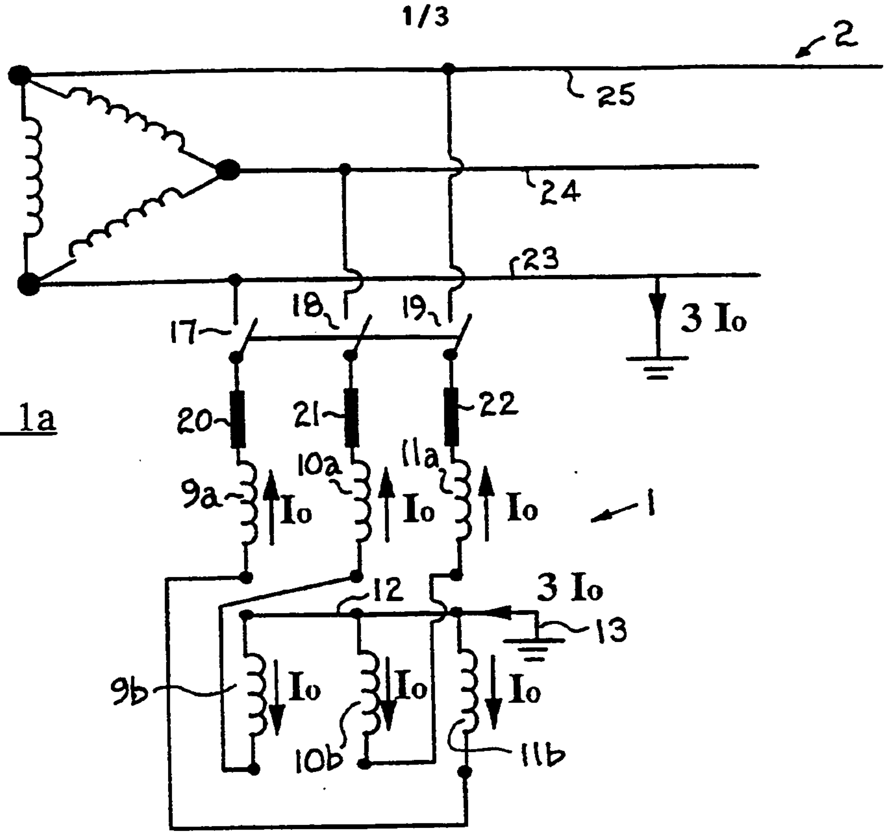

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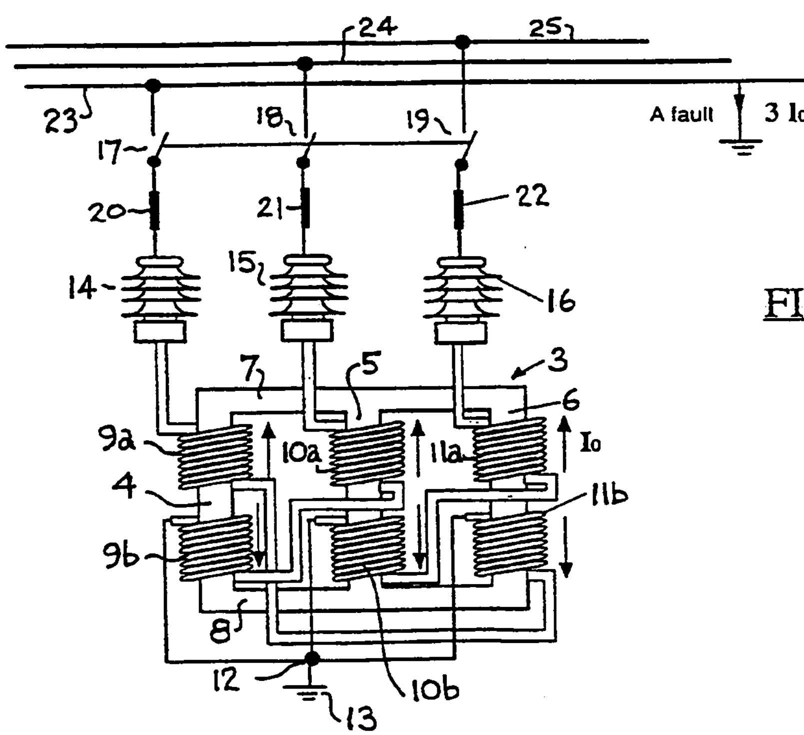
FIG 1a



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13

FIG 2a

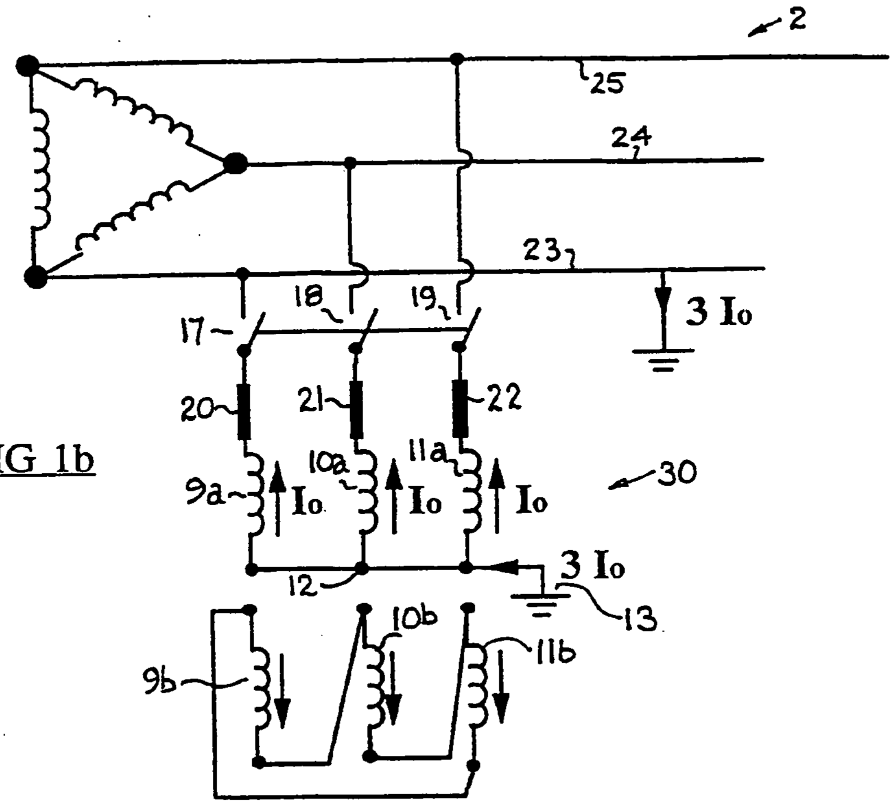

2
25
24
23
3 Io
17
18
19
20
21
22
11a
10a
9a
Io
Io
Io
30
3 Io
12
13
10b
9b
11b

FIG 1b

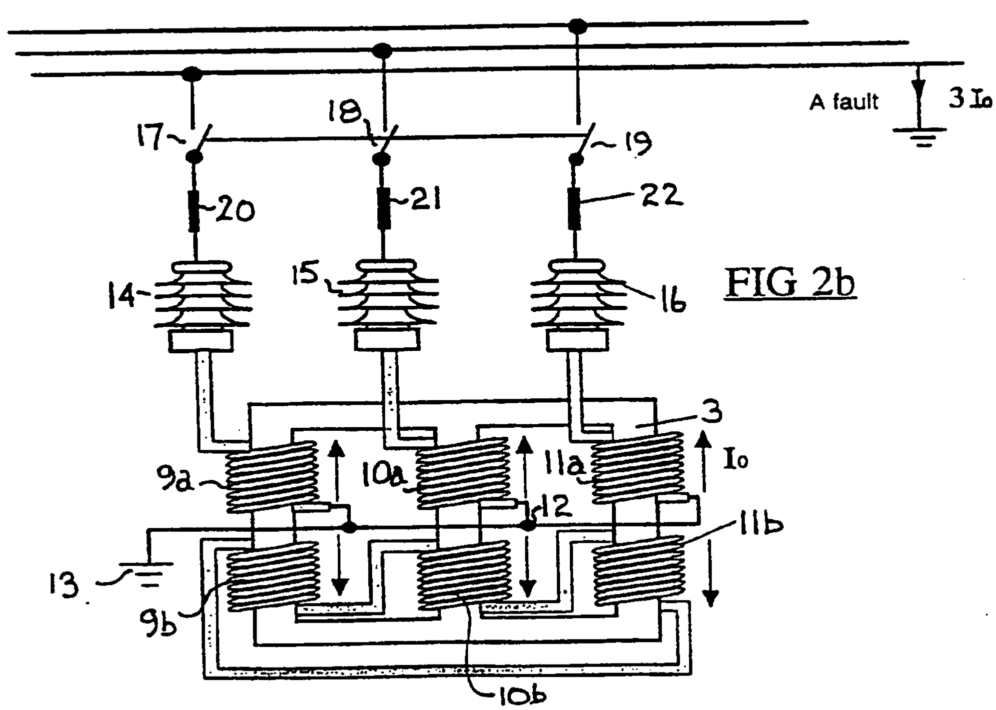

A fault
3 Io
17
18
19
20
21
22
14
15
16
3
9a
10a
11a
Io
12
11b
13
9b
10b

FIG 2b

FIG 5

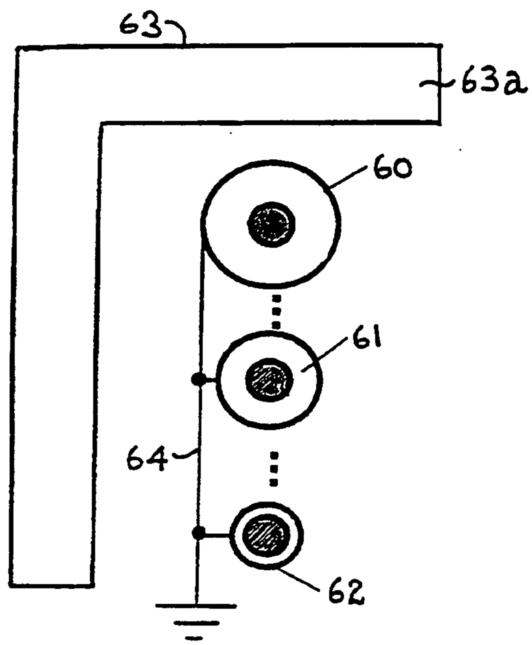


FIG 3

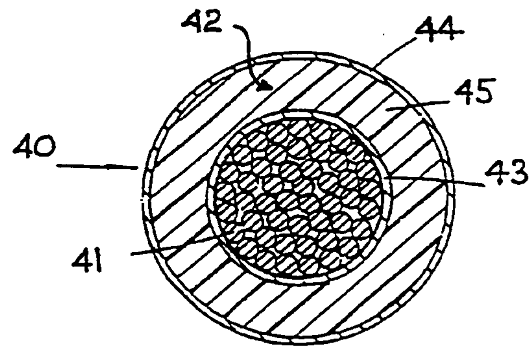
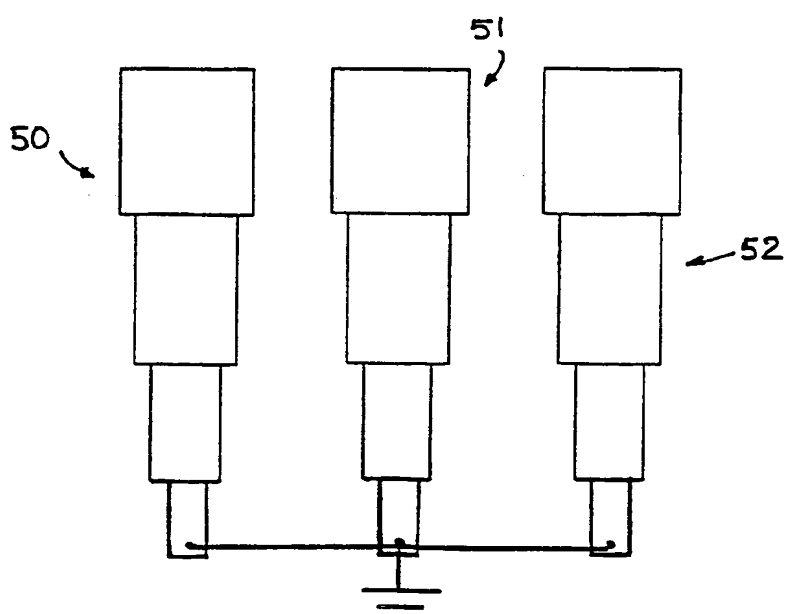


FIG 4



INTERNATIONAL SEARCH REPORT

Inte. .ional Application No
PCT/EP 98/07726

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01F27/32 H01F27/28 H01F36/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01F H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 April 1999	21/04/1999

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 98/07726

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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